REVIEW ARTICLE

Bruises and Carcass Damage

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Abstract

Bruising and carcass damage is a major source of financial loss to slaughterhouses in the United States, approximately $46 million per annum. The absence of easily administered tests to determine where and/or when bruising occurs results in the slaughter plant absorbing carcass damage costs. Rough, abusive handling of livestock accounts for over half of all bruising. Injuries occur through overuse of persuaders, careless transport methods, and faulty equipment. Other elements relevant to carcass loss include branding cattle, abscesses, spreader and crippling injuries, sickness and death during extreme weather conditions, and carcass shrink. The 1979 regulations under the Humane Methods of Slaughter Act of 1978 take into account many of the causes of bruising and carcass damage and its implementation should begin to correct unsuitable conditions associated with preslaughter treatment of livestock.

Economic Factors

General

The economic loss resulting from bruises in the U.S. livestock industry is approximately $46 million annually: $22.4 million, cattle; $22.3 million, pigs; and $1.3 million, calves and sheep (Rosse, 1974). Bruising results from an animal striking its body against a sharp object or being hit by an abusive or careless handler. As long as pressure is maintained in the blood vessels, bruising can occur and has been reported in stunned livestock (Hamdy *et al.*, 1957; Rickenbacker, 1959).

Cattle

A continuous survey on the losses from bruises in beef cattle in several large slaughter plants processing over 80 head an hour is conducted throughout the United States by the Livestock Conservation Institute. Up to one million cattle are surveyed annually. A summary of the *Carcass Damage Fax* (LCI, 1978a) indicates that the economic losses due to bruises are increasing rather than decreasing (Table 1). The upward trend cannot be attributed to fluctuations in the cattle market, although the lower dollar values for heifer losses partially reflects the lower price of heifers as compared to steers.

In the United States, approximately 9.2 and 7.4 sides of beef, respectively,

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TABLE 1 — Bruise Losses in Dollars per 100 Head of Cattle Slaughtered, 1971 - 1977.

Year	Steers	Heifers
1971	$47.90	$33.10
1972	42.80	38.60
1973	45.20	24.20
1974	60.70	47.50
1975	64.40	56.80
1976	73.80	73.30
1977	66.50	60.80
Average: 7 years	**$57.32**	**$47.75**

From: LCI (1978a), *Carcass Damage Fax.*

are severely bruised for each 100 head of steers and heifers slaughtered (Rosse, 1974). Forty percent of all cattle presented for slaughter in New Zealand are bruised, 23% seriously (Marshall, 1977), and in Africa, 12% of all beef carcasses are rejected for export because of bruising (Shaw *et al.*, 1976). Comparisons, however, should take into account possible differences in methodology, breed, sex and type of equipment used in plants. One poorly equipped plant can distort the figures in a given study, and it is therefore best to compare trends rather than absolute values.

Several studies show that approximately 31% of beef bruises occur in the valuable loin and hip area; 36% on the shoulder; 13% on the ribs; and 20% on other parts of the animal (Livestock Conservation Institute, 1974; Rickenbacker, 1959; Stubbs, 1976).

There are two common ways of determining monetary losses from bruising. The first method used in the *Carcass Damage Fax* (LCI, 1978a) is the carcass discount method. When a beef carcass is disfigured by removing bruised meat, the entire side of beef is reduced in value (Figure 1). The average carcass discount for a badly bruised side of beef is $9.00 per side (Livestock Conservation Institute, 1974).

The second way of determining bruise losses is the trim loss method. Trim loss figures are calculated by weighing the bruised meat which is trimmed off and then determining its monetary value. For a precise determination of bruise losses, these figures are more accurate, but the trim loss method requires much more labor than the carcass discount method. Bruise loss figures calculated by the carcass discount method come out higher than figures calculated by weighing meat trimmings. The U.S. national figure of $22 million lost annually from bruises on beef cattle breaks down into $14 million for carcass discounts and $8 million for trim loss (Livestock Conservation Institute, 1974).

Bruise losses can fluctuate greatly due to the high variability in the incidence of bruising. In the *Carcass Damage Fax* (LCI, 1978a), the losses due to discountable bruises varied from $9.00 to $4.70 per 100 head. This variability can often be accounted for by changes in the personal handling of the livestock,

FIGURE 1 — Bruised beef carcass which was discounted $20 due to a "window" bruise in the loin where the butcher had to cut completely through the carcass to remove the bruised meat.

weather conditions, or faulty equipment. The number of animals slaughtered per hour is not an important factor.

Pigs

There is a lack of recent data on bruise losses in pigs because most pork carcasses are made into hams, sausages and other processed products. Previous studies, however, indicated that approximately $11.00 was lost for every 100 head of pigs slaughtered and that 66% of all bruises occurerd in the ham area (Table 2) *[*Livestock Conservation Institute, 1974; Rickenbacker, 1961*]*. Even though these price figures were compiled almost 20 years ago, the loss ratio for the different parts of the animal remains constant.

TABLE 2 — Monetary Losses from Bruises per 100 Head of Pigs Slaughtered

Carcass Location	Monetary Loss†	Percentage of Bruises‡
Ham	$7.38	66%
Shoulder	1.15	10%
Belly (Bacon)	2.03	17%
Loin	.73	7%
Fat Back	.10	

†From: Rickenbacker (1961).

‡From: Livestock Conservation Institute (1974).

Rickenbacker (1961) also found that higher losses from bruising occurred during the summer. An interview with a large pork slaughter plant in the Midwest indicated that 90% of the bruises occur either at the farm or during loading and/or unloading from trucks. Relatively few bruises occur in the slaughter plant, holding pens, sorting chute or in the restrainer.

During the last few years many slaughter plants have started to skin pigs instead of scraping and scaulding them. Skinning is advantageous for several reasons. First, it saves the large amounts of energy required to heat a scaulding vat 130°F to 142°F (54°C to 62°C). Second, elimination of the scaulding vat reduces the waste water load on a plant's sewage treatment system. Third, whereas the skin of scaulded hogs can be used only for suede-type leather, the hides from skinned pigs can be used for top grain, fine leather goods such as coats, gloves and shoes. To receive high market prices, skinned hides must be free from scratches, nicks and tears. Quiet and gentle handling of the live animal is extremely important since pig skins can be scratched and marked very easily. Both stick marks and marks from fighting in the holding pens will lower the value of the hides. More than 40% of the pigs can have damaged hides as a result of fighting (Meat and Livestock Commission, 1975).

Sheep

There is very little recent published material on bruise damage in sheep in the United States. However, a study conducted in England indicated that up to 10% of all fat lambs had carcass damage (Meat and Livestock Commission, 1974). Observations at a large sheep slaughter plant indicate that the great majority of bruises on lambs occur before the animals arrive at the slaughter plant. These bruises are caused by grabbing the wool or the hind leg of a sheep during loading and/or unloading or during the stunning and shackling process. Bruising rarely occurs in the holding pens or while sheep are being lead by a Judas goat.

Rickenbacker (1961, 1962) conducted extensive surveys on the frequency of bruises in sheep (Table 3), and estimated that $4.19 is lost from bruising for each 100 head of sheep slaughtered. He reported that 27% of all sheep bruises were on the leg, which is the most valuable portion of the lamb carcass, while many of the bruises listed under "other" were from neck injuries which occurred during stunning and shackling (Rickenbacker, 1961 and 1962). These figures, however, must be viewed with caution as the sheep industry has declined and changed over the last few years. For example, shackling and hoisting the animal has been replaced by humane stunning methods which would thus reduce bruise losses. In sheep,

TABLE 3 — Monetary Losses from Bruises per 100 Head of Sheep Slaughtered

Carcass Location	Monetary Loss	Percentage of Bruises
Leg	$1.15	27.4%
Shoulder	.34	8.1%
Loin	.70	16.7%
Other	2.00	47.8%

From: Rickenbacker (1961)

the trim loss is only 8.6% of the total monetary loss from discounts on the carcass (Rickenbacker, 1961).

Causes and Prevention of Bruises

Handling

The number one cause of bruises on all types of livestock is rough, abusive handling which may account for up to 50% of all bruises. Good equipment will help reduce bruising but not prevent bruises caused by handlers who rush and excite the animals. An excited animal appears to bruise more easily and the bruise tends to be more severe (Rickenbacker, 1964).

The quality of handling varies considerably and animal handlers have a tendency to revert to rough methods (J. McFarland, personal communication), although the handlers who work in slaughter plants are usually less abusive than truck drivers or people at the auction markets. At one plant which slaughters 40 cattle per hour, with good equipment but rough handlers, the author demonstrated how gentle handling could save $1500 per week in carcass discounts and lost production caused by excited animals refusing to enter the stunning pen. It is hoped that the 1979 regulations pursuant to the Humane Methods of Slaughter Act of 1978 will help to correct the rough handling problems. Federal inspectors will have the authority to suspend plant operations when the Act is violated.

Persuaders have already been discussed in the first paper of this series (Grandin, 1980). For pigs the best type of persuader for use in the stockyard and holding pen area is the canvass slapper (Livestock Conservation Institute, 1974), but care must be taken during cold weather since a frozen slapper can bruise a pig. The plastic slappers on the market avoid this and other problems but can inflict scratches. For cattle the canvass slapper is useful in the stockyard area, but waving a plastic bag on the end of a pole will move cattle very effectively. Electric prods are needed for cattle in the single file chute to the stunning pen; however they should never be used in the holding pen area of the stockyards for cattle or pigs (Grandin, 1980). Electric prods are definitely not recommended for handling sheep; a Judas goat and a noise maker will work very well.

Transportation

Observations and studies indicate that a very high percentage of the bruising results from rough treatment during transport to the slaughter plant and during unloading or loading of livestock. The trend during the last 10 years has been to construct slaughter plants in rural areas in closer proximity to where the farms and feedlots are located; thus the animals are hauled less than 200 miles to the plant. This is especially true for cattle in the southwestern United States and for pigs in the midwestern United States. Records from the Packer's and Stockyard Administration (1978) indicate that in 1976, 66.3% of the fed steers were purchased directly from the feedlot, while 71.5% of the pigs and 75.2% of the sheep were purchased at country buying points. This type of buying reduces stress on the animals because there is less handling. The situation differs with cows, calves and bulls since a high percentage of these slaughter animals are purchased through auction or terminal markets. It is not practical for a slaughter plant to

purchase relatively small numbers of cows and bulls from country buying points or directly from the farmer.

It has been reported that 66% of the bruises on the loin area of cattle occurs during loading or unloading from trucks (Stubbs, 1976) and that there were more bruises on cattle which were hauled by contract truckers than by the slaughter plant's own truckers (Marshall, 1977). Vertical integration of the slaughter and feeding industry may help reduce bruises and damage to animals. Observations indicate that the quality of care and handling of the cattle are improved when slaughter plants buy the cattle and house the animals either in their own feedlots or custom feed them under a contract. Such slaughter plants impose stiff fines for carcass damage and those feedlots which do not improve their handling procedures lose their contracts.

The new double deck tractor trailer trucks which unload through the side instead of through the rear may be a factor in the high percentage of bruised loins (Grandin, 1978). This type of truck trailer is becoming popular in the southwestern United States because it can hold more cattle than a standard double deck which unloads through the rear.

The major problem in side unloading double deck trailers occurs when cattle are being unloaded from the top deck since they have to walk down an internal ramp from the top deck, negotiate a 90° turn, and walk out the door at the bottom of the ramp (Figure 2). If the animals become excited or are rushed by the handler, they can bump their loins against the side of the door, hence a $20 bruise.

The width of the door in a side unloading trailer can also have a significant effect on the amount of bruising (Marshall, 1977). Most side unloading trailers have a 30 in. (75 cm) wide door. At one slaughter plant the owner had custom doors installed which were 42 in. (105 cm) wide and tapered at the bottom (Figure 3). The cattle had no alternative but to walk through the center of the door which in turn prevented the animal from striking the frame.

The most common cause of severe bruising of pigs occurs when they are hauled in the double deck cattle trucks (Grandin, 1978). Pigs will often bunch or pile up, refuse to walk down the ramp, and/or fall down the ramp from the top deck (Figure 4). The safest type of trailers for pigs is one in which the top deck extends all the way to the rear of the trailer where the pigs are unloaded directly off the top deck through a high unloading chute.

A large percentage of bruises which occur in the slaughter plant stockyards after unloading happen while the animals are being weighed. One large slaughter plant installed a truck scale at the unloading chute so the cattle could be weighed while they were in the truck. The plant manager calculated that the truck scale paid for itself in less than a year through reduced bruising. This system can only be used in plants where a truck holds a uniform load of animals which are all being sold for the same price. It would not be practical in some pig plants because sows and boars are often loaded on the truck along with the market pigs.

Cattle Horns and Temperament

Studies conducted in Australia have indicated that horns are one of the major causes of bruises, bruising being almost doubled in groups of horned cattle when compared with groups of polled cattle (Holmes,1976; Meischke et *al.*, 1974;

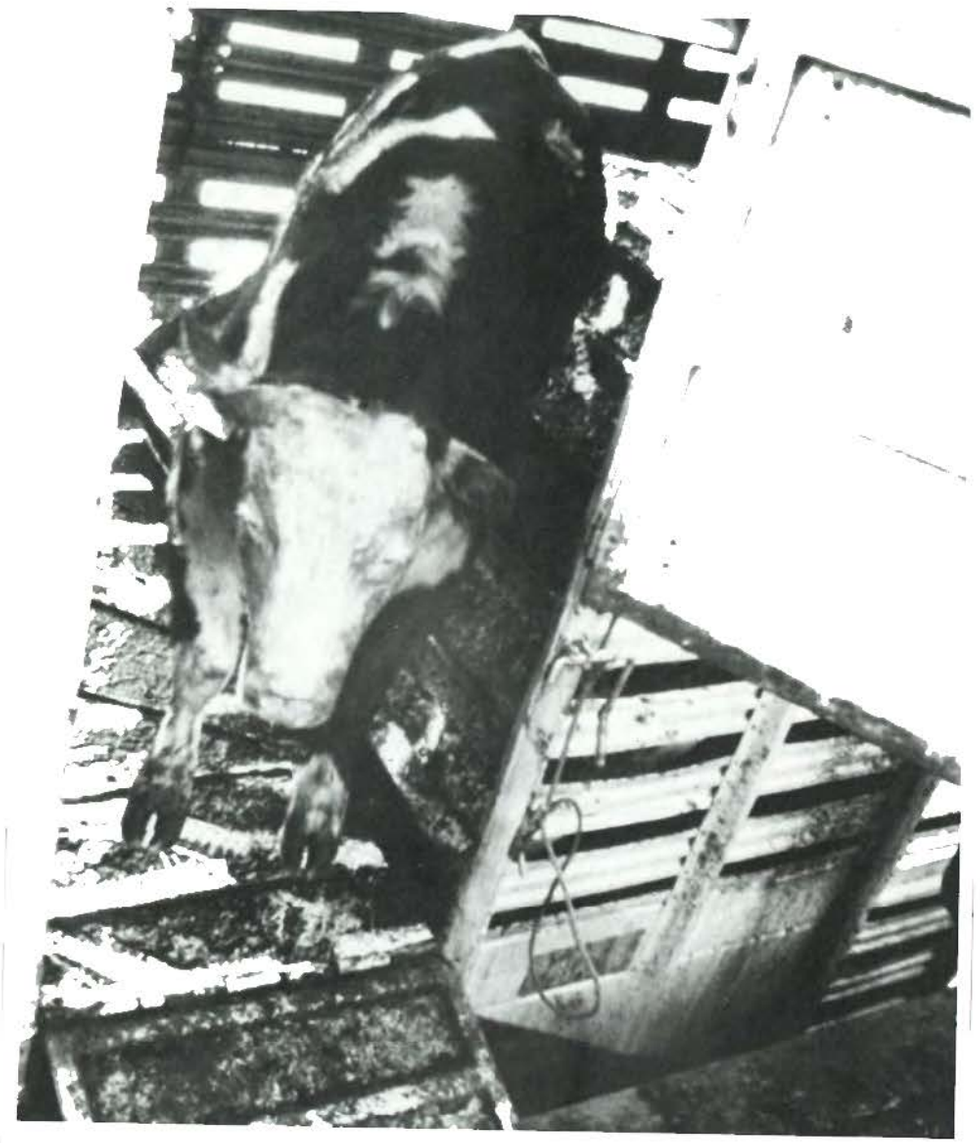

FIGURE 2 — Livestock negotiate a 90° angle in exit from a side loading trailer. Bruising may result if the animal becomes excited and bumps against the side of the door.

Shaw et *al.*, 1976). Table 4 shows the average weight of meat trimmed from 436 cattle which were divided into horned, polled and mixed horned, and polled groups. All the cattle were surveyed under standard commercial conditions.

In an attempt to reduce the bruising problem, many feedlot and ranch managers cut the tips off the horns. However, studies indicate that tipping does not reduce the bruise losses although there are other advantages (Holmes, 1976; Ramsey et *al.*, 1976). For example, when the horns are not tipped they will grow long enough to make it impossible for an animal to pass through a single file chute without turning its head, a feat which is sometimes beyond naive animals.

FIGURE 3 — A tapered door guides the animal through the center; thus reducing bumps and bruises.

The only way to reduce horn-induced bruises is to eliminate the horns either by dehorning shortly after birth or by using genetic lines of cattle which do not grow horns. Complete dehorning of mature cattle is painful to the animals and severely sets back weight gains in the feedlot or pasture. Complete dehorning reduces weight gains by as much as 23 to 30 lbs (10.2 to 13.6 kg), while heavy tipping reduces weight gains by about 19.5 lbs (8.6 kg) [Winks *et al.*, 1977].

The temperament of cattle can have a definite effect on the incidence of bruises and injuries. Holmes (1976) reported that groups of cattle which were very quiet and accustomed to being handled had less than .5 lb (.22 kg) per animal bruise trim loss. In other groups of more typical Australian cattle, the trim losses

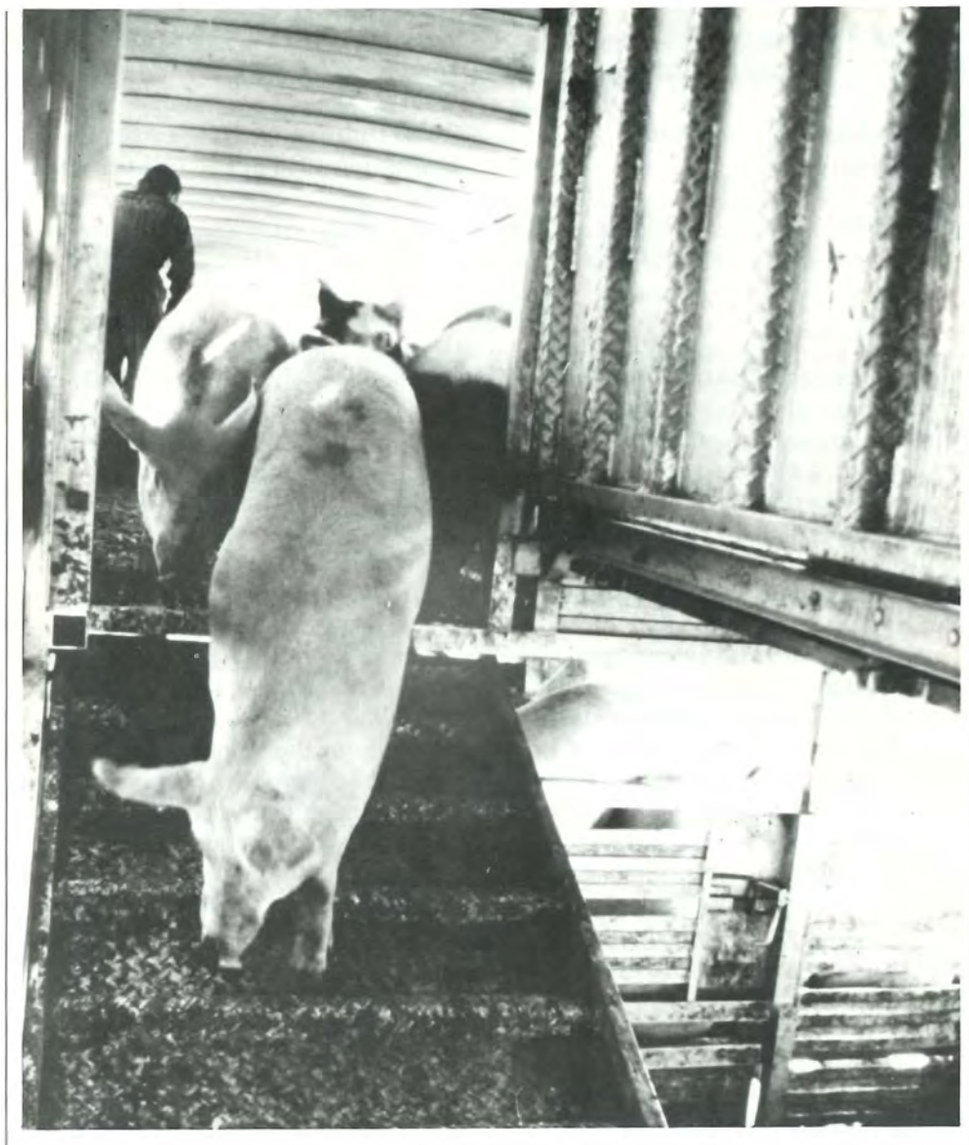

FIGURE 4 — Pigs transported in a double deck trailer will often fall from the ramp during unloading.

per animal were 2.45 lb (1.11 kg), horned; 2.55 lb (1.16 kg), tipped; and 1.5 lbs (0.68 kg) hornless.

Losses from bruises tend to increase if different sexes of cattle are mixed (Meischke *et al.*, 1974; Vowles, 1976). Bulls should be kept separated from cows, and cattle should be sorted by size prior to transport from the farm.

Equipment

Poorly maintained and broken equipment is a major cause of bruises. In wooden pens and chutes, broken boards and protruding nails or bolts can cause bruises. The bruise hazard zone for cattle is 28 to 52 in. (70 to 130 cm) above the

TABLE 4 — The Effect of Horns in Relation to Bruised Tissue Trimmed from the Carcass.

Hornless (Polled)	Horned	Mixed (Horned and Hornless)	Average (All Groups)
2.5 lbs (1.12 kg)	4.0 lbs (1.86 kg)	3.8 lbs (1.75 kg)	3.35 lbs (1.57 kg)

From: Shaw *et al.* (1976).

floor (Livestock Conservation Institute, 1974), and any sharp object which protrudes from this zone should be padded. Animals do not become bruised by pressing up against or bumping into the smooth flat side of a chute or alley.

Gates, a major source of bruising, should be in good repair and swing freely. A gate which drags off the ground or is bent is both a bruise hazard to the animals and a safety hazard to the handlers. One of the most common causes of loin bruises in cattle is the swinging of a gate into an animal as it walks by. The use of completely solid gates in cattle stockyards is strongly recommended; such a gate not only facilitates handling, but has structural rigidity (Grandin, 1980).

In pig slaughter plants, many pigs are injured when they attempt to crawl under a gate. Gates for pigs or sheep should be no higher than 4 to 6 in. (10 to 15 cm) off the floor. In cattle plants the gates should be 12 in. (30 cm) off the floor.

The most common cause of bruising to cattle in the stunning areas is the slamming of vertically sliding gates onto the backs of animals, or putting more than one animal at a time in the stunning pen. Stunning pens designed for more than one animal are a source of a large number of bruises and are not recommended under *any* circumstances. Bruising occurs when the animal which has not been stunned tramples the stunned animal which is lying on the floor. High speed plants should replace this type of stunning pen with a conveyer-restrainer which will usually pay for itself within three years.

Stunned cattle can also become bruised when the animal is rolled out of the stunning pen for shackling (Meischke and Horder, 1976). Bruises on stunned cattle correspond to the areas of the animal which were observed receiving the initial impact when the animal was rolled out. Sharp corners which stunned animals might strike should be eliminated.

Shackling systems which result in excessive jerking of the leg of any type of livestock can damage the joints and cause internal bleeding. In conveyer-restrainer systems, the shackling apparatus should pick up the stunned animals as smoothly as possible. The conveyer-restrainer entrance should also have a smooth transition between the single file lead-up chute and the conveyer; sheet metal on the sides of the lead-up chute should be gradually tapered to conform to the shape of the two conveyers.

Bruise and Damage Tests

One of the reasons why the incidence of bruising remains high is because it is very difficult to determine when and where the bruising occurs. Therefore, the

slaughter plant usually absorbs the cost of bruises which occur in transport, as it is unable to prove that the bruising did not occur in its own stockyard.

Experienced butchers can determine the age of a bruise by its color if it is several days old; however, there is no positive way of determining the age of a bruise which is less than 20 hours old. Hamdy *et al.* (1957) studied electrical conductivity of bruised tissue and found that bruised meat had a higher electrical resistance than normal meat. Although this approach showed some promise, the research was discontinued. With the advent of new sensitive electronic instruments the conductivity method could possibly be developed into a practical, easy to use probe for determining the age of a bruise.

Hamdy *et al.* (1957) also studied the presence of bilirubin in bruised tissue as another measure of determining the age of a bruise. The bile pigment, bilirubin, is formed during the healing process. Older bruises which had started to heal would contain bilirubin. Shaw (1977), in Australia, has developed the bilirubin method into a relatively simple test which could be used in a slaughter plant, but it can only determine if a bruise is more than 48 hours old. In order for the test to be of practical use in the United States, it would have to be able to detect bruises which were less than 24 hours old.

Another possible test for bruised meat utilizes the quantity of light reflected from the meat. Thigpen (1977) has used photodetectors to detect bruises on poultry to facilitate sorting. The age of the bruise did have an effect on the amount of light reflected, but the results of the study were very erratic. A great deal of research is still necessary before a practical instrument can be developed.

Other Carcass Damage

Branding of cattle hides results in a loss of $100 million annually (Kilik, 1976a, b). Each brand ruins approximately one square foot of leather, or 5% of the total area on a large steer hide. A hide with a single brand is discounted $1 to $2 while a hide with multiple brands is discounted $3 to $5. Approximately 70% of the hides in the United States have multiple brands. Kilik (1976a, b) estimates that the leather industry pays $50 million less per year to slaughter plants for hides because of brands.

Branding cattle with hot irons or freeze branding is the only permanent method for identifying beef animals. Branding of range cattle is an absolute necessity to prevent theft, which is a more serious problem today than it was during the frontier days. Some ranchers have tried freeze branding, but the method is cumbersome, requiring either liquid nitrogen or dry ice and alcohol to cool the irons. It is becoming quite widely used for registered breeding cattle but is not practical for range cattle.

Another possible way of identifying cattle uses electronic techniques (Holm, 1977 and 1978). A small electronic implant is placed under the animal's skin with a coded electronic number. These implants can also be modified to record body temperature. Experimental electronic implants have been developed at the Los Alamos Laboratory in New Mexico, but implants can still be removed from range cattle on remote pastures. Electronic identification could be extremely useful for feedlot cattle and dairy cows since the cow's identification number and temperature can be read by pointing a hand-held electronic interrogator at the animal,

thus eliminating handling.

The branding of calves in feedlots is not only painful to the animals but also unnecessary. Several large feedlots in Colorado have discontinued this practice. Instead the animals can be identified with ear tags with a savings of $2 to $3 per animal on hide damage. However, many feedlots in the Southwest still place up to four brands on a calf. A large slaughter plant handling 1000 cattle per day could save $500,000 per year if the cattle were not branded when they entered the feedlot. There is also evidence that branding incoming feeder calves (350-500 lbs) on the ribs may damage the lungs (J. Clark, personal communication).

Abscesses are another cause of carcass damage. Abscesses, which tend to occur in a cluster of animals, are caused by careless, dirty vaccinating methods in the feedlot. The economic result can be a $20 beef carcass discount for each affected animal.

Spreader injuries (e.g., a split pelvis) are caused when an animal loses its footing on a slick floor (Figure 5). A spreader injury not only causes great suffering to the animals, but it can completely ruin both hams in a pig and cause extensive trim losses in cattle. Cattle trucks should have several floor cleats running the full length of the vehicle to prevent spreaders.

Crippling injuries refer to livestock which are too severely injured to walk without assistance. The incidence of crippling is greatest in pigs during the winter because of slick surfaces and because pigs will pile up together for warmth (LCI, 1978b; A. Sabinson, personal communication). This problem can be readily avoided by protecting the animals from chilling winds. A large percentage of crippling injuries also occurs while the animals are in transport.

Weather Factors and Preslaughter Loss

Death losses during transit to the slaughter plant or in the slaughter plant stockyards can be a serious problem, especially with pigs (Allen *et al.*, 1974; Grandin, 1978). A conservative estimate would be that one out of every 2500 head of pigs arrives at the plant dead, or dies in the stockyards at the plant. Death losses per 100,000 pigs during transit or in the slaughter plant stockyards vary from 33.1 in the winter to 51.1 in the summer in the United States (Grandin, 1978). A Canadian survey indicated that 70% of the swine deaths occurred on the truck and 30% occurred in the stockyards (Clark, 1979).

Heat and hot sunny weather or cold freezing rain are the most hazardous conditions during which to transport livestock (D.R. Ames, personal communication; Ames, 1978; Smith and Allen, 1976). Because an animal's hair does not function as an insulator when wet, freezing rain presents more of a hazard to livestock than cold, dry weather. Pigs, which have poorly developed sweat glands, and sheep with full fleece are highly susceptible to heat stress. Therefore, during hot weather, it is preferable to transport those animals at night or in the early morning to avoid the increased heat build-up inside the trucks (Smith and Allen, 1976). When the temperature exceeds 80°F (26°C) pigs should be wet down with sprinkers or with foggers which provide more comfortable cooling and use

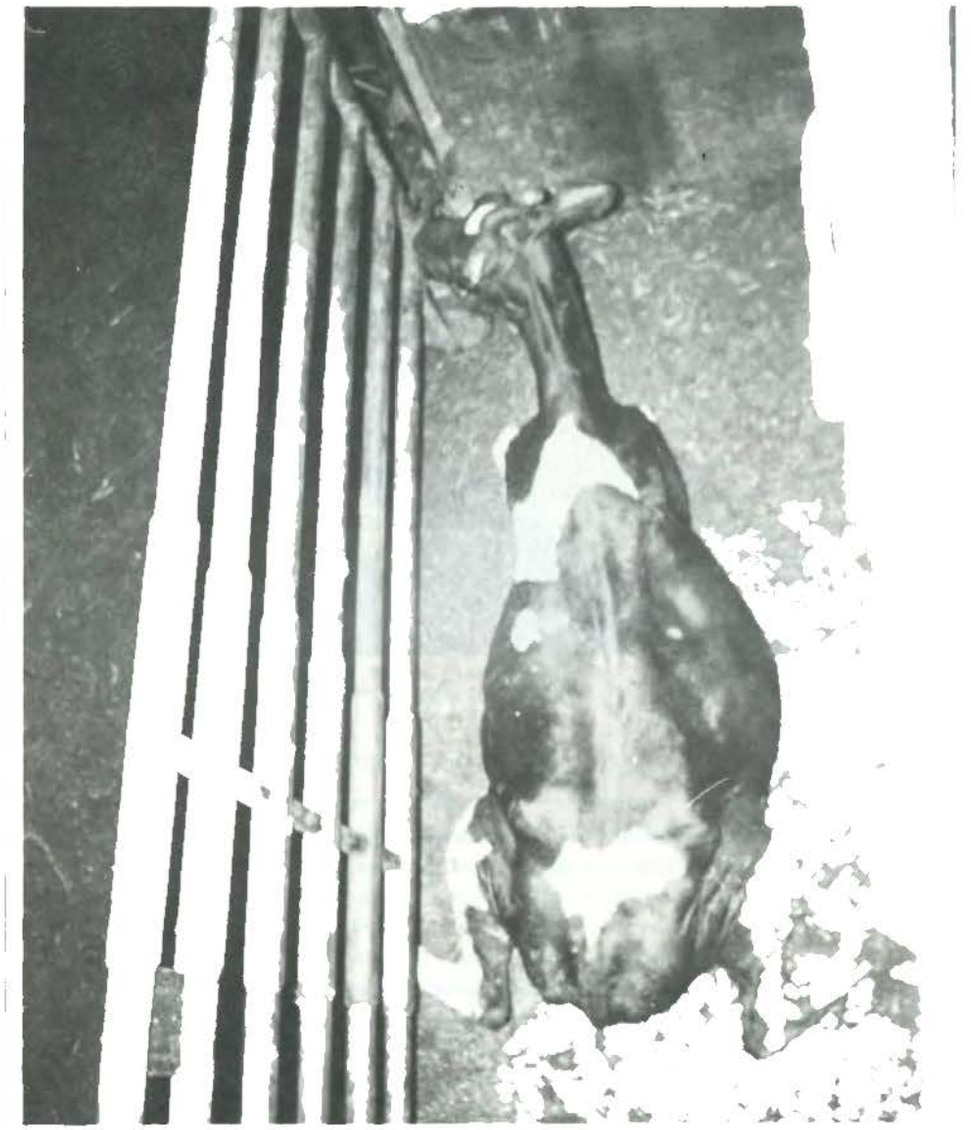

FIGURE 5 — Spreader injury caused by a slick floor.

90% less water than conventional sprinklers. Sprinkling of cattle is usually not recommended unless the temperature is over 95°F (35°C). Woolly sheep can be kept cool with fans.

The Livestock Weather Safety Index (Figure 6) is the only practical, easy to use index which is presently available for slaughter plant operators and trucking companies. New research being conducted by Buffington *et al.* (1977) could lead to the development of a heat stress index which would take into account temperature, humidity, sunlight and air movement. Their present research is being conducted with dairy cows in the humid southwestern United States. The index would be called the Black Globe Humidity Comfort Index, the black globe refer-

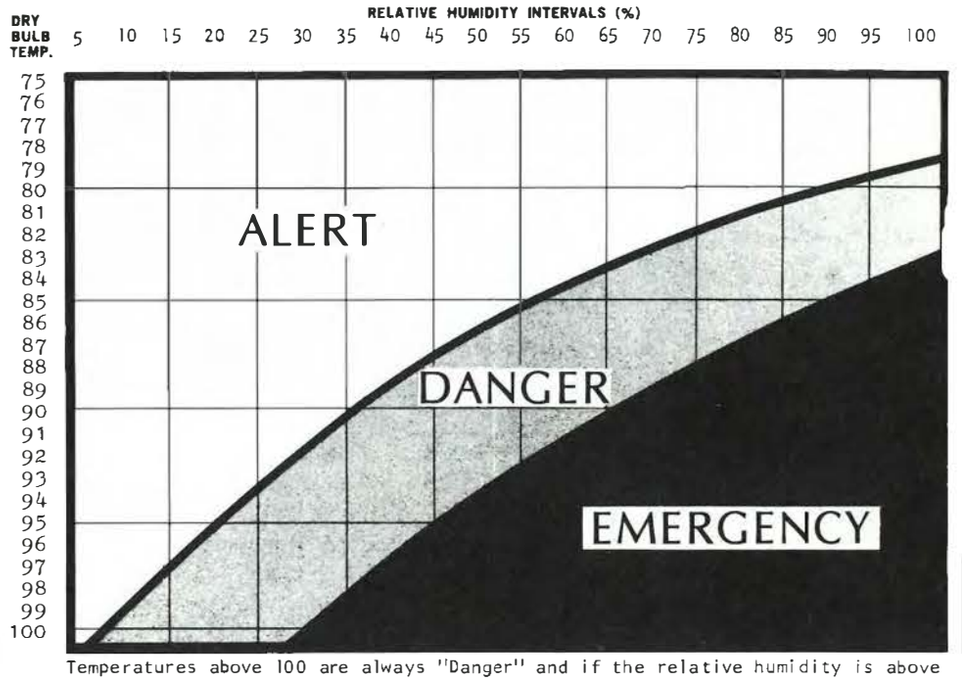

FIGURE 6 -- Livestock Weather Safety Index (Livestock Conservation Institute).

ring to the use of a thermometer installed inside a black copper ball to determine the effect of radiation from the sun on temperature.

Feed and Fasting

It is a common practice in the United States to water but not to feed livestock which are held in the slaughter plant stockyards for less than 24 hours prior to slaughter. The cost of feeding animals which are held for only a short time cannot be economically justified, because most of the shrink during this time is loss of gut fill and tissue shrink has not yet begun.

Studies have been conducted to determine the effects of fasting on the weight loss in live animals (Bowland and Standish, 1966; Callaghan and Thompson, 1940; Carr *et al.*, 1971; Kirton *et al.*,1972). Based on the results of these studies, cattle should be slaughtered within 48 hours after being taken off feed at the feedlot. Pigs and sheep should fast no longer than 24 hours. The animals must have full access to water until 30 minutes prior to slaughter to avoid weight loss (shrink).

Extensive tests have been conducted to determine the effect of heat and humidity on weight loss in livestock (Hahn *et al.*, 1978, Bailey *et al.*, 1978). In sheep, higher weight losses occurred at 82°F (28°C) than at 70°F (21°C). Therefore, in hot climates, the installation of fans is recommended. Pigs incurred the greatest weight loss (12%) at temperatures of 86°F (30°C) or higher (Bailey *et*

al., 1978). During hot weather, pigs will lie outstretched to expose as much body surface as possible to the air and therefore require about 33% more pen space; most large swine slaughter plants provide the pigs with more space during hot seasons. In cattle, higher shrinkage occurred at 82°F (28°C) than at 70°F (21°C) [Hahn *et al.*, 1978]. In most instances, the largest amount of shrink occurred during the first 12 hours. Most of the shrink was excretory and not tissue loss.

Shipping and handling animals which have been fed and watered prior to transport may increase the incidence of sickness and death. In sheep, feed and water should be withheld for 15 to 18 hours prior to trucking on journeys of less than eight hours; however, on longer journeys it is recommended that the animals be fed 2 to 3 hours prior to loading on the truck (Shupe, 1978).

The practice of not feeding the animals has been criticized as being inhumane, although it is difficult to judge just how stressful fasting for one or two days is to an animal. Other psychological stressors in combination with fasting appear to play a more significant role in weight loss than the fasting itself. Range cattle are more prone to shrink than fed cattle because range cattle are not accustomed to being handled, and cattle in strange pens will shrink more than cattle in familiar surroundings (Browson, 1977). In order to assess the stresses related to fasting more thoroughly, studies of corticosteroids and other substances in the blood would need to be undertaken.

Conclusion

Most of the findings on bruise and carcass damage indicate that humane preslaughter handling of livestock would have definite economic advantages and few disadvantages, with the possible exception of the capital installation costs. However, such costs are usually recovered fairly quickly via operating savings. With the adoption of the new 1979 regulations under the Humane Methods of Slaughter Act of 1978, it is anticipated that the abuses and injuries suffered by livestock, and hence the economic losses, will decrease.

There are a number of areas where more research is necessary. For example, a reliable and simple instrument to identify the age of a bruise would provide a greater incentive for freelance truckers to treat the animals more carefully. The question of identification of range cattle is also a major problem from both economic and humanitarian aspects.

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